Claims

[1] An electronic watermark embedding method comprising: a dividing processing step of dividing an electronic image into which an electronic watermark is to be embedded into a plurality of image regions spatially;

an adaptive extraction step of extracting, as adaptive pixels, pixels each having a property of being difficult to visually recognize a variation in a pixel value from each of said plurality of image regions; and

an embedding step of producing a variation between the pixel values of said adaptive pixels in one of said plurality of image regions and those of said adaptive pixels in an adjacent one of said plurality of image regions, and varying the pixel values of said adaptive pixels of said plurality of image regions in a time direction, according to a value of an embedded bit set of an electronic watermark, and of generating an electronic-watermark-embedded image by making the variation in the pixel values of said adaptive pixels vary step by step at a boundary between the two of said plurality of image regions and/or in the time direction so that the variation makes a slow transition.

[2] The electronic watermark embedding method according to Claim 1, characterized in that in the embedding step, the embedded bit set is so expressed as to vary the variation between the two image regions and/or the variation in those of said adaptive pixels in the time direction so that the pixel values of said adaptive pixels in the one of said plurality of image regions have a phase polarity different from those of said adaptive pixels in the adjacent one of said plurality of image regions.

[3] The electronic watermark embedding method according to Claim 1, characterized in that in the adaptive extraction step, pixels each having a brightness level which is difficult to recognize visually even if a brightness variation associated with the embedding of the electronic watermark is added thereto is extracted as the adaptive pixels.

[4] The electronic watermark embedding method according to Claim 1, characterized in that in the adaptive extraction step, pixels each having a large pixel value variation in the time direction are extracted, as the adaptive pixels, on the basis of a pixel value difference in the time direction of the electronic image into which the electronic watermark is to be embedded.

[5] The electronic watermark embedding method according to Claim 1, characterized in that in the adaptive extraction step, the adaptive pixels are extracted from an edge portion of the electronic image into which the electronic watermark is to be embedded.

[6] The electronic watermark embedding method according to Claim 1, characterized in that in the embedding step, the embedding processing is carried out in synchronization with a scene change which occurs in the electronic image into which the electronic watermark is to be embedded.

[7] An electronic watermark detecting method of detecting an embedded bit set of an electronic watermark to be detected from an electronic image into which the electronic watermark is embedded by using a method of dividing said electronic image into which the electronic watermark is to be embedded into a plurality of image regions spatially, producing a variation between pixel values in one of said plurality of image regions

and those in an adjacent one of said plurality of image regions, and varying the pixel values of said adaptive pixels of said plurality of image regions in a time direction according to a value of the embedded bit set, characterized in that said electronic watermark detecting method comprises:

a Gap detection step of detecting, as a Gap value, a pixel value difference corresponding to a pixel value variation in the time direction which is caused by the embedding of the electronic watermark for each of said plurality of image regions of said electronic image from which the electronic watermark is to be detected;

a correlation detection step of detecting a correlation value showing a correlation between a pattern of the pixel value variation in the time direction which is produced between the pixel values in the one of said plurality of image regions and those in the adjacent one of said plurality of image regions, which is caused by the electronic watermark to be embedded in said electronic image from which the electronic watermark is to be detected, and a pattern of the pixel value variation in the time direction of said electronic image from which the electronic watermark is to be detected; and

an embedded bit judgment step of judging said embedded bit set from results of the detection of said Gap value and the detection of said correlation value for each of said plurality of image regions, and judging results of the judgment complementarily so as to determine the embedded bit set finally.

[8] The electronic watermark embedding method according to Claim 7, characterized in that in the Gap detection step, a difference between averages of pixel values of two image data located in a vicinity of noted image data in the time direction

is calculated as the Gap value, the two image data being included in plural image data in the time direction which constitute the electronic image from which the electronic watermark is to be detected.

[9] The electronic watermark embedding method according to Claim 7, characterized in that in the correlation detection step, averages of pixel values of image data located in a vicinity of noted image data in the time direction are sequentially calculated as reference images, the image data being included in plural image data in the time direction which constitute the electronic image from which the electronic watermark is to be detected, and a correlation value showing a correlation between a pattern of variations in the pixel values of these reference image and a pattern of variations in pixel values of the electronic watermark to be embedded into the electronic image from which the electronic watermark is to be detected is calculated.

[10] The electronic watermark embedding method according to Claim 7, characterized in that in each of the Gap detection step and the correlation detection step, a clip process of restricting the detected value so that it falls within a range defined by upper and lower limits is carried out.

[11] The electronic watermark embedding method according to Claim 7, characterized in that in each of the Gap detection step and the correlation detection step, the detection process is carried out in synchronization with a scene change which occurs in the electronic image from which the electronic watermark is to be detected.

[12] The electronic watermark embedding method according to Claim 7, characterized in that in each of the Gap detection step

and the correlation detection step, any image data which is included in the plural image data which constitute the electronic image from which the electronic watermark is to be detected and which has disorder which originates from the scene change is not used for the detection process.

[13] An electronic watermark embedding apparatus comprising:

a dividing processing unit for dividing an electronic image into which an electronic watermark is to be embedded into a plurality of image regions spatially;

an adaptive extraction unit for extracting, as adaptive pixels, pixels each having a property of being difficult to visually recognize a variation in a pixel value from each of said plurality of image regions;

a watermark information generating unit for generating electronic watermark information which produces a variation between the pixel values of said adaptive pixels in one of said plurality of image regions and those of said adaptive pixels in an adjacent one of said plurality of image regions, and which varies the pixel values of said adaptive pixels of said plurality of image regions in a time direction, according to a value of an embedded bit set of an electronic watermark; and

an embedding processing unit for varying the pixel values of said electronic image on the basis of said electronic watermark information, and for generating an electronic-watermark-embedded image by making the variation in the pixel values of said adaptive pixels vary step by step at a boundary between the two of said plurality of image regions and/or in the time direction so that the variation makes a slow transition.

[14] An electronic watermark detecting apparatus for

detecting an embedded bit set of an electronic watermark to be detected from an electronic image into which the electronic watermark is embedded by using a method of dividing said electronic image into which the electronic watermark is to be embedded into a plurality of image regions spatially, producing a variation between pixel values in one of said plurality of image regions and those in an adjacent one of said plurality of image regions, and varying the pixel values of said adaptive pixels of said plurality of image regions in a time direction according to a value of the embedded bit set, characterized in that said electronic watermark detecting apparatus comprises:

a Gap detecting unit for detecting, as a Gap value, a pixel value difference corresponding to a pixel value variation in the time direction which is caused by the electronic watermark embedding for each of said plurality of image regions of said electronic image from which the electronic watermark is to be detected;

a correlation detecting unit for detecting a correlation value showing a correlation between a pattern of the pixel value variation in the time direction which is produced between the pixel values in the one of said plurality of image regions and those in the adjacent one of said plurality of image regions, which is caused by the electronic watermark to be embedded in said electronic image from which the electronic watermark is to be detected, and a pattern of the pixel value variation in the time direction of said electronic image from which the electronic watermark is to be detected; and

an embedded bit determining unit for determining said embedded bit set from results of the detection of said Gap value and the detection of said correlation value for each of said

plurality of image regions, and for judging results of the determination complementarily so as to determine the embedded bit set finally.

[15] The electronic watermark embedding apparatus according to Claim 14, characterized in that the Gap detecting unit calculates, as the Gap value, a difference between averages of pixel values of two image data located in a vicinity of noted image data in the time direction, the two image data being included in plural image data in the time direction which constitute the electronic image from which the electronic watermark is to be detected.

[16] The electronic watermark embedding apparatus according to Claim 14, characterized in that the correlation detecting unit sequentially calculates, as reference images, averages of pixel values of image data located in a vicinity of noted image data in the time direction, the image data being included in plural image data in the time direction which constitute the electronic image from which the electronic watermark is to be detected, and also calculates a correlation value showing a correlation between a pattern of variations in the pixel values of these reference image and a pattern of variations in pixel values of the electronic watermark to be embedded into the electronic image from which the electronic watermark is to be detected.

[17] A program which causes a computer to function as an electronic watermark embedding apparatus comprising:

a dividing processing unit for dividing an electronic image into which an electronic watermark is to be embedded into a plurality of image regions spatially; an adaptive extraction unit for extracting, as adaptive pixels, pixels each having a

property of being difficult to visually recognize a variation in a pixel value from each of said plurality of image regions;

a watermark information generating unit for generating electronic watermark information which produces a variation between the pixel values of said adaptive pixels in one of said plurality of image regions and those of said adaptive pixels in an adjacent one of said plurality of image regions, and which varies the pixel values of said adaptive pixels of said plurality of image regions in a time direction, according to a value of an embedded bit set of an electronic watermark; and

an embedding processing unit for varying the pixel values of said electronic image on the basis of said electronic watermark information, and for generating an electronic-watermark-embedded image by making the variation in the pixel values of said adaptive pixels vary step by step at a boundary between the two of said plurality of image regions and/or in the time direction so that the variation makes a slow transition.

[18] A program which causes a computer to function as an electronic watermark detecting apparatus for detecting an embedded bit set of an electronic watermark to be detected from an electronic image into which the electronic watermark is embedded by using a method of dividing said electronic image into which the electronic watermark is to be embedded into a plurality of image regions spatially, producing a variation between pixel values in one of said plurality of image regions and those in an adjacent one of said plurality of image regions, and varying the pixel values of said adaptive pixels of said plurality of image regions in a time direction according to a value of the embedded bit set, wherein said program causes said

computer to function as

a Gap detecting unit for detecting, as a Gap value, a pixel value difference corresponding to a pixel value variation in the time direction which is caused by the electronic watermark embedding for each of said plurality of image regions of said electronic image from which the electronic watermark is to be detected;

a correlation detecting unit for detecting a correlation value showing a correlation between a pattern of the pixel value variation in the time direction which is produced between the pixel values in the one of said plurality of image regions and those in the adjacent one of said plurality of image regions, which is caused by the electronic watermark to be embedded in said electronic image from which the electronic watermark is to be detected, and a pattern of the pixel value variation in the time direction of said electronic image from which the electronic watermark is to be detected; and

an embedded bit determining unit for determining said embedded bit set from results of the detection of said Gap value and the detection of said correlation value for each of said plurality of image regions, and for judging results of the determination complementarily so as to determine the embedded bit set finally.

[19] The program according to Claim 18, characterized in that the Gap detecting unit calculates, as the Gap value, a difference between averages of pixel values of two image data located in a vicinity of noted image data in the time direction, the two image data being included in plural image data in the time direction which constitute the electronic image from which the electronic watermark is to be detected.

[20] The program according to Claim 18, characterized in that the correlation detecting unit sequentially calculates, as reference images, averages of pixel values of image data located in a vicinity of noted image data in the time direction, the image data being included in plural image data in the time direction which constitute the electronic image from which the electronic watermark is to be detected, and also calculates a correlation value showing a correlation between a pattern of variations in the pixel values of these reference image and a pattern of variations in pixel values of the electronic watermark to be embedded into the electronic image from which the electronic watermark is to be detected.